Nonlinear Tamm states in photonic crystals

S.K. Morrison and Y.S. Kivshar
Nonlinear Physics Centre and Centre for Ultra-high bandwidth Devices for Optical Systems (CUDOS), Research School of Physical Sciences and Engineering, Australian National University, Canberra ACT 0200, Australia.

Optical surface modes are electromagnetic waves localized at the interface separating two dissimilar media where the wave vector becomes complex causing the waves to exponentially decay away from the surface. These general conditions permit surface modes to form in a wide range of systems including layered optical media, optical waveguides, metallic thin films, carbon nanotubes, and photonic crystals. Here, we numerically analyze surface modes, also known as Tamm states [1] in the theory of electronic systems, of a semi-infinite diatomic photonic crystal formed by a square lattice of high dielectric rods in vacuum. We reveal the conditions required to form localized surface modes in this system *without perturbation of the surface layer*. In this way, we demonstrate the existence of *intrinsic surface modes* at a photonic crystal surface. In addition to the study of linear surface states, we introduce a third-order optical nonlinearity to the surface layer and analyze the properties of the *nonlinear surface Tamm states*. We demonstrate the energy threshold, dispersion, and modal symmetries of the surface states, and illustrate their high nonlinearity-induced tunability.

[1] I. E. Tamm Z. Phys. 76, 849 (1932).